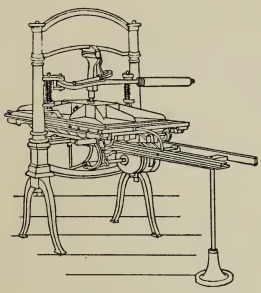
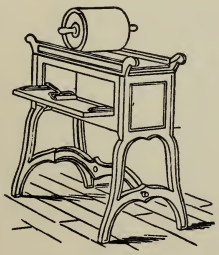
MODERN METHODS OF PRINTING



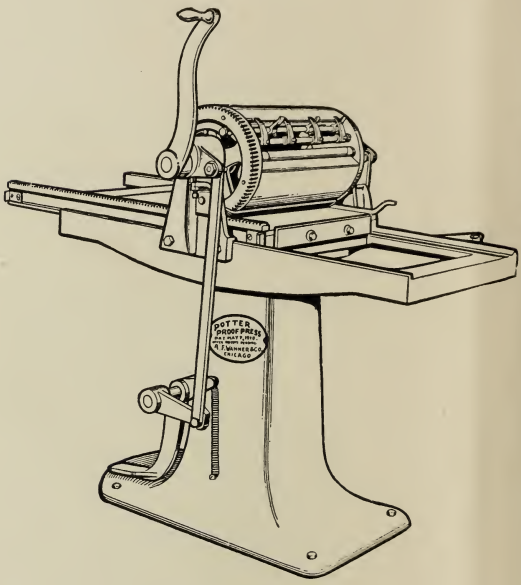
OLD STYLE HAND PRESS

Modernized, and built of iron, this press embodies the principles of the old wooden hand press, except that the impression is made by toggle-joint leverage instead of the original screw. Now used almost wholly for "pulling proofs."



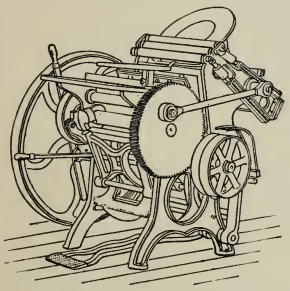
GALLEY PROOF PRESS

A rudimentary style of apparatus used for galley proofs of type and relief plates. When the matter is inked and the sheet laid on, the large roller, covered with felt and resting on side ledges, is rolled over the face of the form.



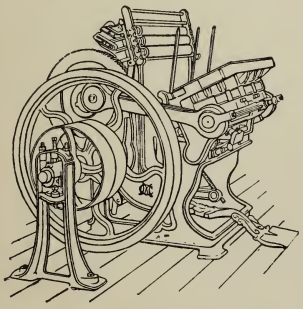
THE "POTTER" PROOF PRESS

A modern appliance, with cylinder and flat bed, for taking proofs of typographic forms, relief plates, etc. Several styles of this press are made, some having self-inking apparatus and feed-table with guides for securing close register on color plates.



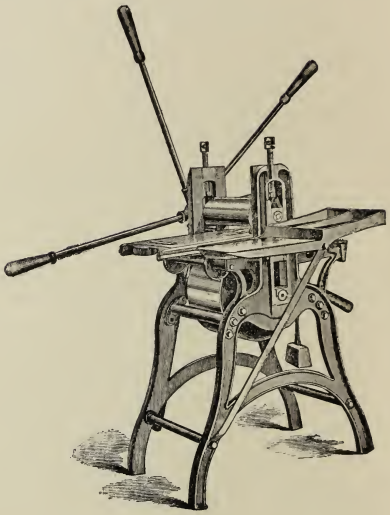
THE "GORDON" PLATEN PRESS

A popular style of machine for small typographic work; the mechanical principle invented about 1858, and since then embodied in various presses by different manufacturers.



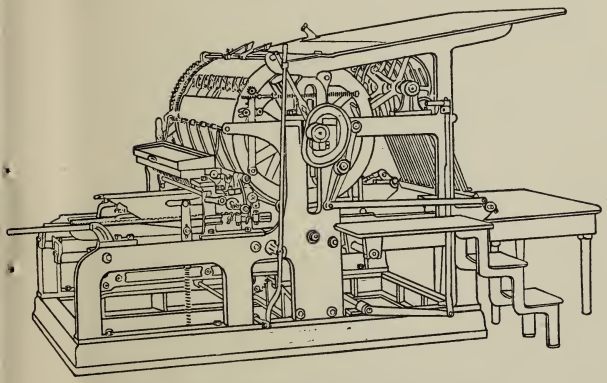
THE "UNIVERSAL" PLATEN PRESS

A later invention than the "Gordon," different in several important particulars, and strongly built for heavy work.



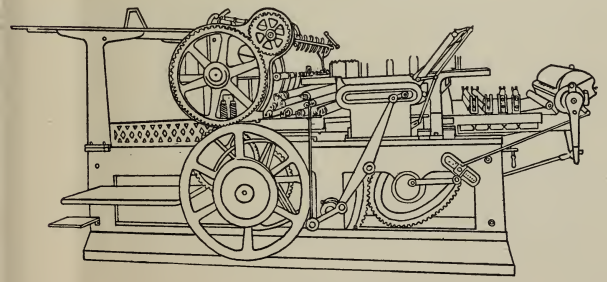
INTAGLIO PLATE PRINTING PRESS

Known as the D-roller press, because of the form of its impression section, this having a curved surface. The engraved plate is attached to the bed which rests upon the larger cylinder underneath and carries it under the D-shaped roller held firmly between the side posts above the bed.



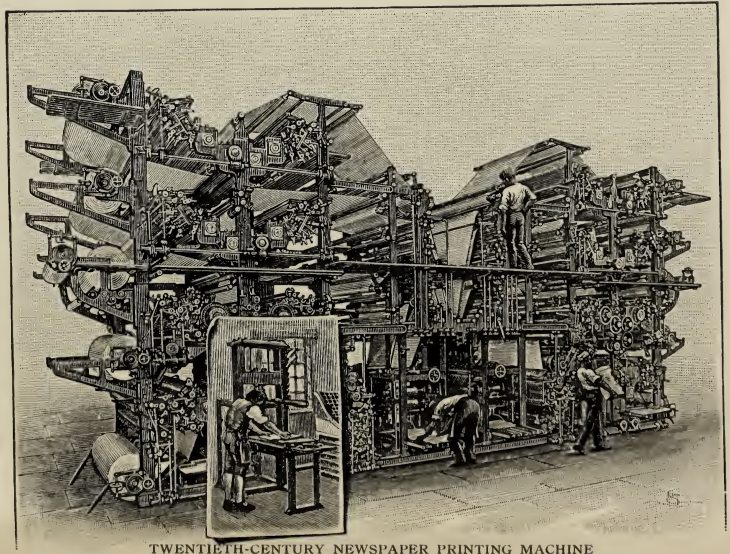
THE "DRUM" CYLINDER TYPOGRAPHIC PRESS

In which the cylinder makes one revolution for each impression. The large cylinder prints with only part of its surface, then rises slightly and continues its revolution while the bed, containing the printing form, returns for the next impression.



THE "TWO-REVOLUTION" CYLINDER

In which the cylinder makes one revolution for the impression and then, rising slightly, makes another revolution without impression, while the bed is returning for the next impression.



TWENTIETH-CENTURY NEWSPAPER PRINTING MACHINE

Compared with hand-press of Benjamin Franklin. From "Leading Facts of American History." By permission of Ginn & Company, Boston, publishers.

MODERN METHODS OF PRINTING

BRIEF DESCRIPTIONS OF THE RELIEF SURFACE, INTAGLIO SURFACE, AND LITHOGRAPHIC PRINTING PROCESSES WITH SOME NOTES ON PRINTING PAPER AND INKS

BY

A. A. STEWART

THE SCHOOL OF PRINTING
NORTH END UNION, BOSTON
1913

MODERN METHODS OF PRINTING

THE term Printing is applied to a great variety of processes for reproducing flat decorations, pictures, and word-matter, by mechanical means. The patterns on wall paper, calico, and pottery, and even the pictures made from photographic negatives, are often said to be printed. For the present purpose, however, the term is limited to such work as is produced by applying ink or color to a prepared surface and transferring this color to paper, card, or other equivalent material by pressure. The power of multiplying copies is usually associated with the idea of printing, which excludes typewriting.

In printing, three different methods are commonly employed, each a separate craft, distinct in theory, process, and application. These are known as:

THE RELIEF METHOD, the chief part of which is typography, or printing from types. This includes also wood blocks and metal plates engraved in high relief, like wood-engravings, zinc line-plate etchings, and halftone engravings.

THE INTAGLIO METHOD, by which the printing is done from polished plates having the lines

cut in the surface and filled with ink. This method includes copperplate and steelplate engraving, copperplate etching, photogravure, drypoint, aquatint, and mezzotint engraving, etc.

THE LITHOGRAPHIC METHOD, chief of which is lithography, or printing from stone. This includes also zincography (printing from metal), the several photo-gelatin processes, and the rubber offset process.

THE RELIEF METHOD

In the relief method of printing the parts which carry the ink, and make the print, stand in relief above the substance out of which they are made, the parts which show white being cut away so that no mark is made on the sheet.

Typography, or letter-press printing, is the method of printing from movable types having letters and other characters cast in high relief. The types are independent of each other, but so made that they may be arranged in endless combinations, and after being once used for one line or page may be separated and re-assembled to print other lines and other pages. Other methods of relief printing require the engraving or preparation of the subject by slow processes upon the printing surface, which, when once made, cannot readily be used for anything else. A page of type, however, may be composed, corrected, locked up for a press, and impressions made in

an hour or less. This may be done after little practice by any intelligent person, with materials which may be readily obtained in all commercial centers. The page also may be as readily molded, and this mold used to produce a duplicate printing form in one piece of thin metal. For the great bulk of book printing this duplicate, called an electrotype, is employed. In this way types sufficient to set up a few pages of this book may be composed, corrected, and the pages locked up and molded, then the types distributed and set again for other pages of the same work, continuing the process for any number of pages. The surface of type forms can also be multiplied by the stereotype process, which is the method now employed for nearly all daily newspapers, as it is the quickest and permits of casting plates in a curved form, so that they may be fastened to the cylinders of fast rotary printing machines.

Up to about thirty years ago type-setting was done almost entirely by hand work, but since that time type-composing machines have been developed so skillfully that the greater part of plain composition on newspaper, periodical, and book work is now done with machines.

ENGRAVING PROCESSES

Closely related to typography in modern practice are wood engravings, line-plate etchings, and halftone etchings. Engravings of these kinds are

in relief, and when made on blocks which bring their surface to the height of type they may be put in the same forms with type, or in separate forms, and printed on an ordinary typographic press. The wood-cut is the older style of engraving, but because of the slow hand-work and its greater cost it has been superseded by the zinc line-plate and the copper halftone.

The zinc etching, or process block, is made by chemical and mechanical means and is extensively used for many kinds of printing. In making the plate, the design is photographed upon a film of bichromated fish glue or albumen, which is afterward spread upon a plate of zinc. This film, after some manipulation, is used as a coating to resist the action of an etching acid. Where the film remains the surface of the zinc is unchanged, and where the film is absent the zinc is etched away. In this manner the face of the plate is eaten away in the white parts and the dark parts are left in relief.

The copy for reproduction is usually drawn on white cardboard with perfectly black ink, and all tones of light and shade are rendered in definite spots and lines of varying sizes. Grained surfaces may also be reproduced.

Halftone engraving is now the most widely used method of illustration. It is done by operations similar to the zinc etching process. The essential difference is the use of a lined or grained

screen interposed when photographing the copy. This screen is placed near the camera plate and the picture is broken up into a mass of small dots. The resulting negative is then placed beside a sensitized copper plate, and after another exposure the picture is transfered to the copper, which is then developed and etched with acid.

A screen of 60 to 80 lines to the inch is suited for the rapid work and cheap paper of daily newspapers; screens of 135 to 200 lines, for smooth coated papers printed on slower presses, give the fine results seen in commercial and periodical printing. The finer the screen, the shallower the plate can be etched, therefore the paper must be smooth and the ink fine in order to print clearly.

PRESSWORK

Relief printing is done on machines of two distinct classes; the platen, or flat surface, and the cylinder. The old hand press consisted of a flat bed upon which the type-form was placed; after being inked and the sheet laid on, the form was subjected to impression by another plane surface. The modern platen press embraces the same principle with the operations applied mechanically instead of by hand labor. Cylinder presses are of two classes. One style consists of a flat bed holding the printed form, which passes back and forth beneath a revolving cylinder carrying the sheet and giving the impression.

The other consists of two facing cylinders, on one of which a curved printing form is placed; the other cylinder, having a smooth surface, imparts the impression as the sheet passes between the two cylinders revolving in opposite directions. This latter style of press is the kind employed for daily newspapers, large edition periodicals, and advertising matter issued in large quantities. The flat-bed-and-cylinder style of machine is the kind in most common use for book and commercial work. It is made in many varieties by different manufacturers, and is the kind upon which the largest part and the best grades of typographic printing are done. The mechanical platen press is used for jobbing and miscellaneous small work, while the hand press is largely employed for taking proofs of type and engravings, and for work of which only few copies are required.

THE INTAGLIO METHOD

By the intaglio method of printing the design is cut in the surface of the plate, the lines or dots thus engraved being filled with the ink, the face of the plate then wiped clean, and the paper, slightly damp, pressed on the plate under the curved surface of a roller press. By this pressure the paper is forced into the sunken lines and takes up the ink, so that the printing has a slightly embossed or raised appearance. This

method is in every respect the reverse of printing from type, and gives results in delicacy of line and brilliance and depth of color not obtainable by other methods. The ink fills the lines in a compact body and does not spread out under pressure; whereas with type the pressure of printing from a fine line covered with ink tends to weaken the color and leave blurred edges.

There are several methods of engraving on copper and steel plates, each employed according to the nature of the design. The engraving is done by hand with sharp tools, or gravers, producing precise lines of varying thickness, as for script lettering. A succession of uniform lines, straight, curved, or waved, are made on a ruling machine, and stippling is done by minute punctures, the dots being larger or smaller, close or open, to give varying tones of color, Another method is to etch the surface with a corroding acid. The plate is covered with a coating through which the design is cut, and the metal afterward eaten away where it is exposed. Because of its greater freedom of manipulation, its quickness, in comparison with the hand engraving method, and the sketchy nature of etched lines, this latter method is popular with artists, and is employed largely for wall pictures and works of art.

Copper- and steel-plate printing, being almost entirely hand-work and not easily adaptable to rotary or other mechanical methods, is slow and

costly. The kinds of work done are chiefly personal cards, wedding and society cards, announcements, and stationery.

The presses used are not at all like those used for printing type forms and relief plates. Each print requires the ink to be worked into the engraved lines, the surplus ink cleaned from the face of the plate, the sheet laid on, and the impression taken. The output of a single press is limited to a few hundred copies a day. This method is the same now as when it was first invented in the fifteenth century. The tools are the same; the D-roller press is practically the same, perhaps better made; the workman wipes off his plate in the same way. In bank-note printing and a few special lines of work new machines have been introduced, but a great part of this kind of work is today done by the original hand methods.

Steel-plate printing employs practically the same methods as copper-plate work, the engraving being done on a plate of polished steel instead of copper. The method is used for bank notes, postage stamps, etc., and was formerly largely used for portraits and fine illustrations, though for this latter purpose halftones and photogravures have now largely superseded steel plates, because of the smaller cost.

Steel dies for stamping note paper, envelopes, and similar work, are also manipulated by the

same general methods. The steel is soft, so that it can be cut without much difficulty with hand tools. After the engraving is done, the steel is put through a hardening process, to prepare it for withstanding the wear of printing. As the design is sunk in the metal, it is necessary to use a counter die to force the paper into the sunken parts to take up the ink. The impression from an engraving of this kind will show the printed design raised in distinct relief on the surface of the paper. The counter die is made usually of a substance known as tar-board, a piece of which is laid on the steel die and a strong impression taken. The edges of the tar-board are then trimmed away gradually up to the face of the design, so that the impression will be chiefly at the actual point of printing.

Die printing is commonly done with a stamping press operated by hand, but there are now several embossing and die-stamping presses in which most of the operations are automatic, and the inking and wiping of the die is done mechanically instead of by hand.

PHOTOGRAVURE PRINTING

One of the most popular and beautiful reproductive methods for illustrative purposes is the intaglio process known as photogravure. There are numerous variations in the details of this process as carried on by different operators, but in a gen-

eral way the method is by chemically treating a gelatin, albumen, or asphaltum film, upon which the subject has been photographically fixed, on a metal printing plate.

The metal plate, which is usually a sheet of polished copper free from all traces of grease, etc., is prepared by graining; that is, a finely powdered resin dust is deposited on the surface of the plate and fixed by heating, so that the particles form a slightly rough or grained ground. On this ground a photographic film is placed and manipulated in such a manner that the different parts of the picture are represented by differences in the thickness of the gelatin. The light parts of the picture are represented by the greatest thickness, the half tones by lesser, and the dark parts by the thinnest film. The plate is painted on the back and sides by an acid-resisting varnish and placed in an etching bath. The face of the plate is thus etched by the strong acid. Where the gelatin is thinnest the acid etches deepest, and where it is thickest the copper is etched least. Sometimes hand work is necessary on the plate, to smooth down the light parts by burnishing or scraping the copper, by adding detail, or intensifying the dark parts by cutting into the copper with a fine tool or small-toothed wheel.

As the soft copper used is not durable enough to withstand the wear of a large number of impressions, the plate is usually steel-faced by giving it an electrolytic coating of steel.

In printing, the ink is forced by means of a dabber or roller into the hollows etched into the plate and the surplus ink wiped from the upper surface and the margins. In the grain all over the plate are little points or teeth of copper where the particles of resin dust were burned on, and these hold the ink and prevent it from being wiped away from the hollow spaces when the surplus ink is cleared off. Damp paper is then laid on the plate, backed with blanketing, and the impression made by means of a heavy iron roller in a special hand press.

Machine-printed photogravure work is being developed to some extent, and some work of this kind has been done from curved surfaces; but, like other copperplate work, the bulk of photogravure printing is done on hand presses.

THE LITHOGRAPHIC METHOD

Under the head of the plane-surface method of printing, the chief process is lithography, or printing from flat stones. There are several processes closely allied to this, in which surfaces other than stone are used, such as zinc, aluminum, rubber, gelatin, etc.

The theory of lithographic printing is based upon the repulsion of grease and water, and the production of the design depends upon chemical manipulation of the printing surface. The kind of stone employed is a fine limestone which has

a natural affinity for grease. The design to be printed is put on the stone with specially prepared fatty inks, which dry on the surface of the stone and render that part insoluble in water or spirits and is durable even under considerable friction. The surface is then subjected to the action of a weak acid which slightly etches or roughens the blank portions, after which it is washed with gum arabic to give these parts a slight grease-resisting quality.

The preparation of the design on the stone may be done in several ways: by drawing it on with a special crayon, or pencil, or with pen and lithographic ink; and by writing, drawing, printing, or photographing on prepared paper and then transferring this to the stone.

LITHOGRAPHIC PRESSWORK

The process of printing from lithographic stone requires moistening the surface with water, which is absorbed by the blank parts and repelled by the hard, greasy lines of the design. The printing ink is then applied and is repelled by the wet parts but adheres readily to the lines and spots of the design. The stone thus prepared is ready to make its impression on the paper.

Like other methods of printing, lithographic work was formerly done on hand presses, but since 1860 power presses have been invented and many improved details have been employed.

The lithographic hand press has a movable bed, like that of the typographic hand press, but the impression is made with a straight-edge scraper at the press-head, instead of with a flat platen. The bed moves under this scraper, which extends across the width of the stone and imparts great pressure on a small area at a time.

The first operation, when printing, is to moisten the surface so that the subsequent inking will leave the ink only on the design. When sufficient ink has been applied, the sheet is laid on, the tympan turned down, and the bed moved in under the scraper. The back of the tympan is of leather, zinc, or brass, and is slightly lubricated to allow the scraper to pass over it with as little friction as possible. Lithographic ink rollers are made by covering wooden or iron cores with felt or flannel, the outside inking surface being a fine grained or glazed calf leather.

Lithographic power presses are similar to cylinder presses used for typographic work, but with some necessary differences in detail of construction. A lithographic stone, after being used, may be ground down and have a fresh surface prepared for another design. Thus, different thicknesses of stones must be used, and the distance between the bed and the cylinder must be varied to accommodate these differences. The cylinder is covered with a thick, elastic blanket or sheet of indiarubber. The necessary moisture is applied

to the stone by wet rollers, which are at the opposite end of the press from the inking rollers. These wet rollers consist of cores wound with several thicknesses of flannel and covered on the outside with cotton or linen fabric.

Chromo-lithography is the process by which a picture is printed in several colors. A separate stone is used for every color printed, and in reproducing paintings of many colors the skill of the lithographic draftsman consists in his selection of such colors as will reproduce the original in the fewest printings. The comparative ease with which transfers may be made from one stone to another, and the accuracy which may be secured in registering a number of colors over each other, have especially adapted lithography for color work.

Stones of good quality for lithographic work are becoming more and more difficult to obtain, so that zinc and aluminum, suitably prepared, are now largely used instead. These thin metallic surfaces have the great advantage of being adapted to the curved surfaces of rotary machines, and therefore the printing may be done at high speeds.

GELATIN PRINTING

A printing process analogous with lithography is known as collotypy, in which a film of gelatin deposited on a ground glass or metallic surface

is used instead of stone. The basis is a thick glass plate coated with a gelatin film containing a bichromate. This is dried in the dark. The design is put on this gelatin surface by means of a photographic negative, and the film is affected by light in its different parts according to the lights and shades of the picture. Where rays of light strike this sensitive film, that part becomes more or less insoluble and will refuse to absorb water, while the parts which have not been exposed will remain absorbent. The exposed film is then washed and dried out again, and again dampened with a solution of glycerin and water, which is absorbed by the light parts and repelled by the dark parts. When thus prepared, a roller containing greasy ink is passed over the gelatin surface; the ink will adhere to the insoluble parts and refuse to stay on the damp parts, similar to the action of inking a lithographic stone. The printing is done on a small apparatus like a lithographic hand press. The gelatin-covered plate rests on a bed to which a thin brass or other metallic tympan-frame is hinged. After inking and laying on the sheet, this tympan with its necessary blanketing is turned down and the bed drawn under a straight-edge scraper which covers the width of the plate,

Printing with gelatin surfaces gives the fine, soft effects of photography, with the permanence of colored pigments. Being almost entirely hand

work, it is necessarily slow and expensive, and is employed only for small editions.

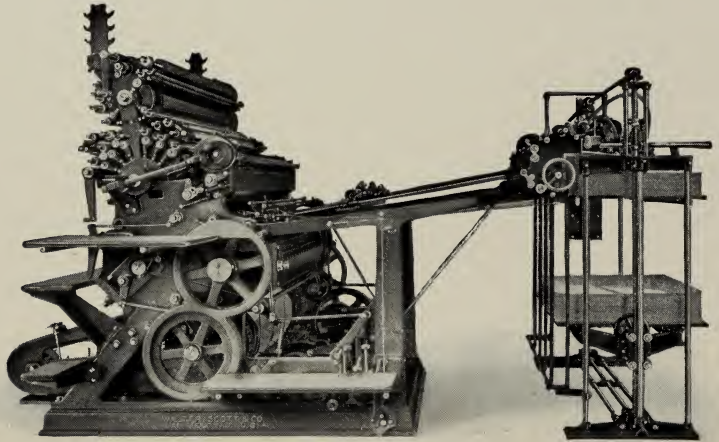
Slight variations of the gelatin lithographic process are known by other names, such as heliotype, albertype, phototype, autoglyph, etc.

THE OFFSET METHOD

This method of printing has recently undergone rapid development, especially in this country. It is one of the variations of the lithographic principle, employing a flat surface, chemically treated, for holding the design to be printed, and a rotary machine with three cylinders for the printing operations. One cylinder carries a zinc plate containing the design, transferred from an original copy; this cylinder prints on the rubber covering of a second cylinder, which, after receiving the impression, prints, or offsets, on to the sheet of paper that is carried around by the third, or impression, cylinder. Two sets of rollers are used, adjusted close to the cylinder holding the zinc plate. One set of rollers supplies ink to the plate, while the other set dampens it, as in ordinary lithography.

THE THREE-COLOR PROCESS

This is a method of reproducing, photo-mechanically, with only three printing plates, a picture or drawing in any number of colors. The process includes making three photographic negatives of



THE SCOTT ROTARY OFFSET PRESS
with sheet-feeding attachment

the copy to be reproduced. Each of these negatives is then used to make a halftone plate which will print one of the three primary colors. The three colors, yellow, red, and blue, are used because their mixture in varying proportions will produce all other colors of the spectrum.

In making these negatives, colored screens or filters are used between the negatives and the copy. For the negative used to make the yellow plate a colored filter is employed to shut out the yellow rays and allow only the red and blue rays to pass through and affect the film. For the red-plate negative another filter admits only the blue and yellow rays, and for the blue-plate negative a filter admits only the yellow and red rays. From these negatives other films are made, and these in turn are used to make halftone plates.

The halftone plates are then printed one over the other in prescribed order. When rolled with an ink-roller holding ink of the required color, the etched surface of each halftone plate takes on its different parts just the right amount of ink to combine with the colors printed by the other plates and produce the effect in the original.

A fourth color plate may be added and the blue plate of the three-color series printed in a paler blue, using the fourth plate to print black over the other three colors.

Great skill is required to make the plates, and they require more or less special attention in

etching different parts in order to obtain correct color values. Expert skill is required also in the printing of the plates to produce good results — just the right color and quantity of ink, just the right impression on each part, and absolutely exact register; for, while many of the halftone dots in the plates must be printed over each other to give the darker colors of the picture, in the lighter parts the smallest dots in one plate must be printed between and beside those of another plate without overlapping or smudging.

Color work is sometimes done with two halftone plates, or with one halftone and a flat tint block, registered over each other, giving two tones of one color or two contrasting colors.

OTHER METHODS OF ENGRAVING

Wax Engraving. A common method for making printing plates for maps, charts, diagrams, and other classes of work. It is less expensive than other methods of engraving, and may be done quickly. A polished plate of copper or brass is covered with a thin film of specially prepared wax, and upon this the design may be made either by photography, hand drawing, or other transfer method. The engraving of the wax surface is done by sharp-pointed tools, a ruling machine, or, in the case of lettering, ordinary types are pressed in the warm wax, one letter or one word at a time. In this manner the wax-covered

plate becomes a mold, the large blank spaces are "built up" in the same manner as an electrotype wax mold, and it is then put in an electric bath and a copper shell deposited on its face. A printing plate is made by the same general procedure as with an ordinary electrotype.

Chalk-Plate Engraving. This is a quick, cheap method of making simple relief plates for illustrative purposes. The picture or design is drawn on a steel plate coated with a chalk preparation. The drawing is done with a fine steel-pointed tool, which cuts through the chalk all the lines it is desired to print. The plate is then used as a matrix and stereotype metal cast from it, which results in a stereotype block with the engraved lines standing in relief on its surface. This method depends upon the skill of the draftsman who must do his work largely freehand, and it is not easily adapted for fine or exact lines.

MANUFACTURE OF PAPER

Printing papers are made from several varieties of vegetable fiber, those most commonly used being linen and cotton rags, hemp, jute, and wood. The raw material necessary for paper is cellulose, the indestructible cell-membrane of plants. The quality of paper is dependent, first, upon the quality of the cellulose, and next, upon the manner in which it is manufactured. As cotton fiber contains the greatest amount of pure cellulose, it

makes the best paper. The great bulk of paper in common use, however, is made of wood.

After the raw material is sorted and cut up, the process is continued by grinding, bleaching, beating, and boiling until the fibers are reduced to a soft pulp. As it was made by hand in early days, this pulp was dipped from a vat with a shallow mold having a screen bottom. When the water drained away, the remaining film of interlaced fibers was deftly turned out, pressed, and dried. Hand-made paper is still produced in small quantities for special editions of fine books, note paper, etc., but the process is so laborious and costly that its use is necessarily limited.

Paper is now made almost entirely by elaborate machinery, in which the prepared pulp flows on to a frame or cloth of fine wire that moves continually forward on rollers. This wire frame has a shaking motion and allows the water to escape while holding the fibers evenly spread out. As the pulp passes along it is taken up between a pair of couch rolls which press it into a self-supporting sheet. It next goes, in an endless sheet, between press rolls and steam-heated cylinders which dry it rapidly. The finishing process is done in a variety of ways, according to the quality of the paper and the nature of the surface desired.

Wood pulp is of two distinct classes: mechanical and chemical. The mechanical or ground

pulp is made by feeding pieces of wood against a rapidly-revolving grindstone over which water is flowing. The pulp is then screened in order to eliminate splinters and chips. This product is of low quality, as it contains a great deal of the gummy portions of the original wood, and the fibers are short and inflexible. The chemical pulp is made by chipping the logs and cooking the chips in large digesters with strong liquors at a high temperature. After cooking, the pulp is washed, screened, and bleached. This process dissolves the resinous and gummy matters, and leaves the cellulose fibers in a practically pure state. These fibers are much better than the ground wood, as they are freed from substances which soon decay, and are longer, stronger, and more flexible.

There are several different kinds of chemical wood pulps, varying in character according to the kinds of wood used and the cooking process.

Mechanical pulp and chemical pulp are often used together, the quality of paper depending on the proportion of low grade and better pulp. Wood pulp is also mixed with rag pulp for many grades of paper, the substances being used in varying proportions, according to the quality and finish desired. Rag stock and long-fiber wood pulp may have some short-fiber stock added to fill up the minute interstices. Clay or other mineral may be added as a filler, to give closer con-

sistency, smoother finish, and extra softness to the sheet. Mineral filler gives extra weight.

Laid paper is made on a screen in which the wires are laid parallel, with a large wire crossing at regular intervals. The large wire-marks show light lines when the sheet is held to the light.

Wove paper is made on a frame in which fine wires are woven together like the threads of ordinary cloth. Distinct wire-marks do not show, as in laid paper. Most printing paper is now made on this kind of a frame, as the wire-marks of laid paper are liable to show in printing solid or flat surfaces.

Laid and wove papers differ only in the wire-mark; the same quality of material may be used in both, although the laid pattern is oftener seen in writing paper.

The device known as a "water-mark," which may be seen when a sheet is held to the light, is really a wire-mark. It is made when the pulp is first formed into a sheet, in the same way as the lines in "laid" paper, by means of a wire device. The paper is slightly thinner and more transparent where the wire makes its impression.

A rough, feather edge, known as deckle edge, is formed where the pulp flows against the "deckle" which keeps the pulp from running off the sides of the screen. This edge is sometimes left on the better grades of book and cover paper intended for special books and pamphlets. Machine-made

paper has this deckle edge on two sides of the whole sheet, while hand-made paper has the deckle on all four sides.

An important difference in the structure of hand-made and machine-made papers is the grain or general position of the long fibers. In hand-made paper the fibers interlace and cross each other in many directions, so that the sheet will usually fold both lengthwise and crosswise without showing a difference in the folding quality or flexibility of the sheet. In machine-made paper the tendency of the fibers is to assume the direction in which the pulp flows on to the screen, so that the paper has a distinct grain with the fibers running in one general direction. In many grades of machine-made paper the flexibility of the leaves in a bound book will depend upon whether the grain runs across or lengthwise of the page. Usually the fold should be with the grain, as the paper bends smoother and makes a more flexible hinge for the leaf. When folded across the grain the fold will show a rough, broken edge. In cover stock and heavy papers the relation of the fold to the grain is often an important consideration.

FINISH OF PAPER

Although the surface finish of paper will make a very great difference in its appearance, it often gives no indication of its quality. Each kind of

finish, however, is usually made with a special grade of stock. But sometimes a cheap material is given a fine finish, while the best grade of raw material may have a rough, unpretentious finish.

Clay is used largely in printing paper to fill up the pores between the fibers and make a smoother finish. It is objectionable because it adds greatly to the weight and reduces the strength and durability of paper.

There are six usual styles of finish to ordinary printing paper: antique, machine, English, calendered, smooth coated, and dull coated.

Antique is a rough surface, the paper being left light, bulky, uncalendered, and without "filling."

Machine finish is the surface given as the paper passes between the ordinary machine rollers, but without the final calender finish.

Calendered paper is passed through a set of extra rollers, or calenders, which subject it to a heavy pressure, the degree of polish being governed by the number of rollers and the amount of pressure.

So-called English finish is the highest machine finish, the next degree of smoothness being supercalendered, which is the highest degree of finish on an uncoated surface.

Coated paper is a machine-finished paper that is covered (by a special operation) with a fine clay paste and polished in a stack of friction calenders.

Dull (or "cameo") finish is given by a clay coating and pressure without the polishing operation.

Plate finish is made by placing the paper between zinc plates and subjecting it to a heavy pressure. This does not give as fine gloss as supercalendering, but makes the sheet more even in thickness and well adapted for fine illustrations.

Linen, grain, pebble, and "novelty" finishes are given by running the paper between rollers or other apparatus which have their surfaces prepared to impress the desired pattern.

CLASSES OF PRINTING PAPER

Papers now used for printing are divided into four general classes, viz.: writing papers, book papers, cover papers, and news. These are again each subdivided into a number of more or less specific classes.

Writing papers are known as ledger, bond, linen, and "flat" papers, used for office forms, stationery, and commercial purposes. The quality of the raw material ranges from new linen rags for the best grades down to wood pulp for the cheaper grades.

Writing papers are sized with a glutinous preparation, made of animal or vegetable fats, to give stiffness to the paper and to prevent writing ink from spreading on it. Size may be mixed in the pulp in the vat, or the sheet may be sized by passing through a bath of size, when it is said to be

tub-sized. Highly sized paper is hard and does not receive the impression of printing ink as readily as unsized paper.

Book papers embrace a wide range in quality, from the cheapest wood to pure linen rag stock. In style of finish, they range from the roughest antique through all degrees of smoothness to highly polished coated. Sizing is used in some grades, but usually it is unsized.

In book papers there are three common colors: natural, white, and toned. Natural is bleached pulp without adding any coloring matter. White is made by adding a small quantity of bluing. Toned color (india tint, etc.) is produced by adding some reddish or orange coloring matter.

Cover papers are made of rag and wood pulps, usually heavier and stronger than common printing paper, and colored in endless varieties, for the most part in dark colors, and finished in surfaces from the highest glaze to that of the roughest fabric. For convenience in handling, as well as because of the relatively smaller quantities used, it is made in smaller sheets than book paper.

RELATION OF PAPER TO PRINTING METHOD

The adaptability of paper to any special printing method depends largely upon the surface and to a lesser degree upon the character of the paper stock. A relief printing form requires relatively little ink and little pressure in order to leave its

full impress upon a smooth paper. As the paper becomes rougher, more ink is needed to fill up the small pores of the surface and more pressure to force the ink into the rough surface. On a smooth paper, also, the relief hair-line leaves the impress of its face only; when the printing form is forced into a rough surface the sides of the lines show more or less, and consequently give a thicker impression. So that the principle holds, in relief printing, that the finer the lines the smoother the surface must be to print clearly.

Soft, unsized paper takes the inked impression with relative ease; when it is slightly damp it takes impression still easier. When paper is well sized, as in writing paper, the increased hardness makes it more difficult to print; it then needs stronger impression and also an ink with increased adhesiveness in order to cling to the harder, less absorbent surface.

For intaligo printing only the better qualities of paper are suited, and these are of medium rough finish. Coated or enameled papers are not at all suitable.

For lithographic printing the paper is made smooth (not polished) and soft, yet strong and with a small quantity of sizing. For lithographed labels and similar work the paper is finished on one side only.

By the offset printing method delicately toned pictures may be printed on rough surfaces. One

of the advantages of this method is that fine pictures may be printed on a rough surface and give all the softness of photographic printing.

The condition of the paper at the time of printing is always a matter for consideration in careful presswork, especially in the case of work done in several colors. Paper will expand in moist atmosphere and contract when exposed to dry air. When the sheets must go through the press several times and the atmosphere of the workroom varies from dampness to dryness, or vice versa, the condition of the paper often will change enough to cause many difficulties.

PRINTING INK

In a general way, printing ink is a combination of boiled oil and a black or colored pigment. It is not like writing ink, but is more like paint, with certain qualities which are necessary for its particular uses. It must distribute in a thin film and it must work clean, with a certain tackiness and without spreading away from the parts to which it is applied; it must adhere to the printing surface readily, and yet come off as readily and adhere to the paper; it must not dry too quickly while being used, but it must dry reasonably hard within a short time after being applied to the printed surface.

The best inks are made with boiled linseed oil; others have linseed and rosin oils combined,

and rosin oil only is used for the cheaper grades. Different pigments have been used for black ink — black minerals, lampblack, ivory black and carbon black — but carbon black is now mostly used because of its density and covering qualities. Sometimes a touch of blue pigment is added to give black ink a deeper color.

In making colored inks, the pigments are obtained from mineral vegetable, and animal substances, each of these furnishing certain colors well adapted for special purposes. Almost all colors, however, can now be made artificially from coal-tar dyes, and these are used to a great extent in the ordinary grades of printing.

Composition and presswork by pupils in the School of Printing, North End Union, Boston, 1913.